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SPRAYING FOR APPLE DISEASES AND THE CODLING MOTH IN THE OZARKS.

BY

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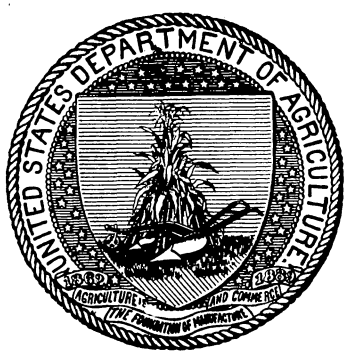

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
Washington, D. C., January 26, 1907.

SIR: We have the honor to transmit herewith the manuscript of a bulletin entitled "Spraying for Apple Diseases and the Codling Moth in the Ozarks," by W. M. Scott, of the Bureau of Plant Industry, and A. L. Quaintance, of the Bureau of Entomology. We recommend that this be published as a Farmers' Bulletin. The work was conducted under the joint direction of our two Bureaus and has resulted in a remarkably successful demonstration of methods of controlling a number of the most serious fungous and insect pests affecting the orchards of this important fruit region.

The accompanying illustrations are necessary to a clear understanding of the text.

Respectfully,

B. T. GALLOWAY,
Chief, Bureau of Plant Industry.
L. O. HOWARD,
Chief, Bureau of Entomology.

Hon. JAMES WILSON,
Secretary of Agriculture.

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SPRAYING FOR APPLE DISEASES AND THE CODLING MOTH IN THE OZARKS.

INTRODUCTION.

During the past fifteen or twenty years the Department of Agriculture and many of the State agricultural experiment stations have been devoting much time to the study of apple diseases and insects and to conducting practical experiments in their control. Much information on this subject has been accumulated and made available for the use of orchardists through publications and correspondence, and the apple-growing industry of the country has been enormously benefited thereby. The increasing losses due to insects and diseases, following their more general dissemination and an increased food supply, has rendered their control imperative in the successful growing of this fruit, and perhaps no other crop derives such a large percentage of benefit from the use of remedial and preventive measures.

Although there are many apple growers who are successfully controlling the diseases and insect pests of their crop, perhaps the majority have not availed themselves of the remedies at hand, or are not securing satisfactory results, largely owing to lack of sufficient attention to details or to imperfect use of remedies. While some benefits have followed careless spraying, the results in many cases have not appeared to warrant the necessary outlay in expense and labor, resulting in discouragement to the grower and apparent discredit to the recommendations. Indeed, some fruit growers have come to believe that the recommended measures are entirely without merit.

The treatment for the important fungous and insect troubles of the apple mostly takes the form of spraying, and, as will at once appear, great variation is possible in the comparative thoroughness with which applications may be made. Good results also depend upon the proper preparation of sprays, the efficiency of the pumps, and the time applications are made. It is seen, therefore, that several factors are involved, the neglect of any one of which may result in partial or total failure. It has therefore appeared desirable to carry the work beyond experimentation and actually demonstrate on a commercial

scale to orchardists the proper use and efficiency of control measures that have been evolved from careful experiments.

Accordingly, work of this character was planned by the Bureau of Plant Industry and the Bureau of Entomology for the season of 1906 and was carried out in apple orchards in the Ozark regions of Arkansas and Missouri, in the latter State in cooperation with the Missouri State Fruit Experiment Station. Similar work was also carried out in several counties in southeastern Nebraska, in cooperation with the Nebraska Agricultural Experiment Station. In the work herein reported the writers have had the assistance of Messrs. J. B. Rorer, F. W. Faurot, and Dudley Moulton.

SCOPE OF THE WORK.

The predominating troubles in the apple orchards of the Ozark region are apple scab, bitter-rot, apple blotch, leaf-spot, and, among insects, the codling moth. A plan of treatment was formulated which should as nearly as possible give protection from all these affections, namely, the application of Bordeaux mixture and an arsenical at such times as a knowledge of the affections indicated that spraying was necessary.

This work in Arkansas was conducted in Bentonville and vicinity, in the orchards of Mr. H. W. Gipple, Capt. George T. Lincoln, and Doctor Alden. In the Gipple orchard 200 Ben Davis and 100 Winesap trees were sprayed. In the Lincoln orchard 250 trees, about equally divided among the Jonathan, Ben Davis, Gano, and Givens varieties, and in the Alden orchard 200 Ben Davis trees were treated.

In Missouri the orchard of Fassnacht Brothers, at Springfield, and that of Mr. J. E. Hansell, at Fordland, were selected. In the Springfield orchard, 75 Huntsman and 200 Ben Davis trees were used, and in the Fordland orchard 400 Jonathan, 100 Gano, and a few Ben Davis trees were treated.

ORCHARD CONDITIONS IN THE OZARKS.

The growing of apples in the Ozarks has within comparatively recent years become a very important industry, and in that region are to be found some of the largest apple orchards of the country, in some instances covering from 500 to 1,000 acres. As a rule, however, the orchards are much smaller, ranging from 40 to 100 acres. The principal commercial varieties grown are Ben Davis, Gano, Jonathan, and Winesap, the Ben Davis and Gano varieties predominating. Trees are generally planted about 30 feet apart and come into bearing early, usually in from six to eight years. Growth is fairly vigorous, but trees do not as a rule reach large size, in part due to their early bearing. Many orchards have not had adequate cultivation, but have

been permitted to grow up in shrubs, weeds, and briers. The effect of this neglect was generally apparent during 1906, the crops in neglected orchards being very light or there being no crop, whereas in well-cared-for orchards the yield has invariably been good.

As a rule, sufficient attention has not been given to the control of diseases and insects, and under such conditions these have become quite abundant and destructive. While numerous orchardists have supplied themselves with spraying outfits and have sprayed their trees, many very soon abandoned the practice, not having secured satisfactory results. The principal difficulty appears to have been lack of information concerning the troubles to be controlled and failure to comprehend what constitutes thorough spraying.

PLAN OF WORK.

A plan of treatment was adopted which called for sprayings with Bordeaux mixture having an arsenical added, except in the first treatment, as follows:

First application, when cluster buds opened, but prior to blooming.
Second application, as petals fell.
Third application, seven days later.
Fourth application, thirty days after petals fell.
Fifth application, June 25.
Sixth application, July 17.
Seventh application, August 11.

Specifically these treatments were designed to control the apple scab, codling moth, leaf-spot, apple blotch, and bitter-rot, all of which affections are quite destructive in Ozark orchards.

The early treatments were for the apple scab and the first generation of the codling moth. The later treatments, beginning with June 25, were for bitter-rot, apple blotch, leaf-spot, and the second brood of codling moth.

In practice it was not found possible to make the applications entirely as planned, but the scheme was approximately carried out, as will be detailed in the consideration of the respective affections.

BITTER-ROT.[a]

INJURY.

Bitter-rot is a fungous disease of the apple, which causes decay of both green and ripe fruit, rendering it unfit for market. It was reported as seriously destructive in Illinois as early as 1869, and with the increased development of the apple industry since that date it

[a]For a more extended account of this disease and successful experiments in its control, see Bul. 93 of the Bureau of Plant Industry, U. S. Dept. of Agriculture, by W. M. Scott.

has appeared at irregular intervals with increasing severity in various sections of the more southern parts of the apple belt. In recent years the losses from this malady have been specially severe, amounting during some seasons to several millions of dollars. The fact that it may suddenly attack and destroy the entire crop of an orchard as the fruit approaches maturity has brought about a general dread of the trouble, and has caused a depreciation in the value of orchards in infested regions.

DESCRIPTION.

The disease first appears on the fruit as very minute yellowish-brown spots, frequently surrounded by purplish or reddish areas. These spots, which are circular in outline, gradually enlarge, assume a dark brown color, and, owing to a shrinking of the invaded tissue,

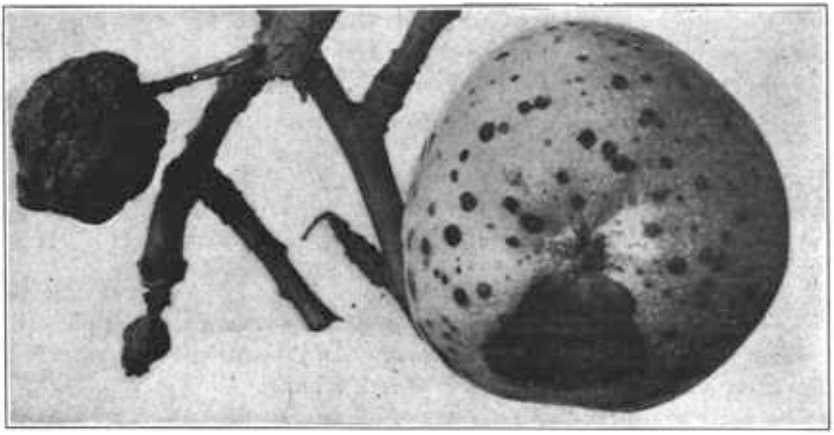

FIG. 1.—A Yellow Newtown apple affected with bitter-rot, and a mummified fruit of the preceding year's crop. (From Scott.)

become more or less depressed. By the time the spots reach one-fourth to one-half inch in diameter, minute, black, slightly raised fruiting pustules begin to appear, arranged in more or less concentric rings. These soon break through the skin, discharging pinkish masses of spores, and as the disease advances other rings of pustules are produced. The pink spore masses are more in evidence during periods of fair weather, as they are readily washed off by rains and are even dissolved out by heavy dews, leaving visible the small black openings of the pustules.

Only a single diseased spot may appear on an apple, but frequently there are several of varying sizes, and in a serious outbreak the fruit may be literally peppered with small points of infection and numerous larger spots. In such cases a few of the spots grow rapidly and envelop the others, and, although coalescing more or less, retain their individual

outline, each producing its concentric rings of fruiting pustules. Most of the diseased fruits fall to the ground by the time or before they are half decayed, but some may become entirely rotten, dry up in a mummified condition, and hang on the tree for a year or more. This disease is illustrated in figure 1, which shows an apple affected with bitter-rot and a mummified fruit from the preceding year's crop.

THE CAUSE.

The familiar spots on the apple known as bitter-rot are caused by the growth in the tissues of the fruit of the fungus *Glomerella rufomaculans* (Berk.) Spauld. and v. Schrenk. The infection starts from very minute spores, which, falling on the surface of the apple, germinate in the presence of moisture, and the resulting tube-like growth penetrates the skin and immediately begins to branch and grow rapidly, destroying the invaded tissue and soon producing the circular, brown, sunken area already noted. The fungus penetrates toward the center of the apple about in proportion to its rate of growth as seen on the surface, and eventually the fruit, as it decays, becomes filled with the minute, almost colorless threads of the fungus.

After a time spore-bearing branches of the fungus are produced near the surface of the diseased spot, and these soon rupture the skin, giving forth pinkish masses of spores or conidia, by which the disease is principally spread. From a single diseased spot are produced many millions of spores, sufficient to furnish infection under certain conditions for an entire orchard. On the decayed apples which have fallen to the ground the perfect stage of the fungus is produced during the autumn and perhaps also the following spring. This stage serves to carry the fungus over winter and its spores are perhaps a source of infection of the new crop of apples. With the warmth and moisture of spring and early summer the fungus in mummified fruits on the trees resumes growth, producing conidia or summer spores, which serve to infect the new crop.

Canker.—The bitter-rot fungus also occurs on limbs and twigs of the apple tree, affecting the bark and cambium and producing what are known as cankers. The diseased area is sooty black, sunken, and from 1 inch to several inches in length, and the bark usually becomes cracked. Both winter and summer spores are formed in these cankers, which doubtless constitute an important source of infection of the fruit.

CLIMATIC INFLUENCES.

Bitter-rot is essentially a hot-weather disease, and its period of infection is mostly during the months of July, August, and September. Injury from it is rarely noticed before the middle of June, but with

suitable weather conditions it becomes increasingly marked as the season advances. Hot, showery weather is ideal for the development of the disease. Moisture is necessary for the germination of the spores, and a high temperature favors the growth of the fungus.

DEMONSTRATION SPRAYING FOR BITTER-ROT IN ARKANSAS.

The demonstration work was done at Bentonville, Ark., and treatment for bitter-rot was included in all the demonstration spraying at that point, but only the results obtained in the orchard of Capt. George T. Lincoln will be here discussed in detail.

This orchard was not at first selected for the general demonstration work, and it was not until July 10, after considerable infection of the fruit had taken place, that spraying was begun. On July 6 Captain Lincoln called our attention to a slight outbreak of the disease on his Jonathans, and upon investigation on July 8 from 1 to 20 affected fruits were found on each of various trees of the Jonathan, Gano, and Ben Davis varieties, and on July 10 as high as 50 diseased fruits per tree were counted on the Jonathan trees. The other variety, the Givens, appeared to be free from rot at that time. Arrangements were immediately made with Captain Lincoln for spraying a block of 250 trees about equally divided among the four varieties, and leaving 6 trees of each variety untreated as checks. Some of these check trees were left together in two rows running a third of the way through the block, near the center, while the others were distributed in other portions of the block. The trees were ten years old and in good condition, having been thoroughly pruned and well cultivated, but during the past two seasons the orchard was in clover sod.

The treatment.—The entire block, excepting the check trees, was sprayed with Bordeaux mixture on July 10, July 26, and August 9, and the Givens trees, which mature their fruit some three to four weeks later than the other varieties, received an additional application on August 27. The Bordeaux mixture was composed of 5 pounds of copper sulphate and 5 pounds of lime to 50 gallons of water, to which 2 pounds of arsenate of lead were added for protection against the codling moth. The trees were thoroughly sprayed, especial care being taken to reach every apple so far as practicable. For the first two applications a good hand pump, mounted on a 100-gallon tank and equipped with two 30-feet leads of half-inch hose and double Vermorel nozzles, was used. The other applications were made with a gasoline-power sprayer, with a 200-gallon tank, three 35-feet leads of ⅜-inch hose, and triple Vermorel nozzles, a tower being employed to reach the tops of the trees.

The results.—Although the disease was well established in the orchard before treatment was begun, the results were quite good,

exceeding expectations. The spread of the disease was immediately checked by the first spraying and held under control by the succeeding applications. The invisible infections that had taken place before the treatment was begun developed into rotten spots under the coating of Bordeaux mixture, and a few fresh infections took place just before the crop was picked, the mixture having been partly washed off. On the other hand, the disease continued to develop on the unsprayed trees, new infections taking place from time to time through the season, so that very little sound fruit was left on these trees at picking time. Rains occurred at frequent intervals, furnishing ample moisture for infection.

The apples from 6 sprayed trees and 3 unsprayed or check trees of each variety were classified into rotten and sound fruit, the term "sound" applying to all fruits not affected with bitter-rot. The windfalls were included, and the apples of each class were both counted and measured. The results are shown in Tables 1 to 4:

TABLE 1.—*Comparison of sound and bitter-rot affected fruit from sprayed and unsprayed trees of the Jonathan variety, Lincoln orchard, Bentonville, Ark., 1906. Fruit picked August 29 and 30.*

Date of spraying and tree number.	Yield.	Sound apples.	Diseased apples.	Percentage of sound fruit.
Trees sprayed July 10 and 26 and August 9:	*Bushels.*	*Number.*	*Number.*	
No. 1	15.76	1,278	144	89.87
No. 2	18.26	1,563	253	86.06
No. 3	18.76	1,526	163	90.34
No. 4	10.26	749	103	87.91
No. 5	13.76	1,394	17	98.79
No. 6	24.50	2,164	309	87.50
Nos. 1 to 6 combined	101.30	8,674	989	89.76
Trees not sprayed:				
A	5.875	3	1,276	.23
B	9.35	135	1,670	7.47
C	5.875	50	1,298	3.70
A, B, and C combined	21.10	188	4,244	4.24

Table 1 shows the results from 6 sprayed Jonathan trees, separately and combined, and 3 unsprayed trees of the same variety, separately and combined. It will be noted that the average percentage of sound fruit from the sprayed trees is 89.76, while that of the 3 unsprayed trees is 4.24, the crop from the latter being almost entirely lost. It will be remembered that the Jonathan trees were the first to become infected, as many as 50 diseased fruits having been found on some trees at the time of the first application, and perhaps others had invisible points of infection. This largely accounts for the 10 per cent of loss sustained on the sprayed trees. Indeed, it was not expected that such a high percentage of sound fruit could be obtained after the disease had gained such a foothold.

TABLE 2.—*Comparison of sound and bitter-rot affected fruit from sprayed and unsprayed trees of the Gano variety, Lincoln orchard, Bentonville, Ark., 1906. Fruit picked September 6.*

Date of spraying and tree number.	Yield.	Sound apples.	Diseased apples.	Percentage of sound fruit.
Trees sprayed July 10 and 23 and August 9:	*Bushels.*	*Number.*	*Number.*	
No. 1	22.50	1,877	6	99.68
No. 2	19.26	1,594	2	99.87
No. 3	13.26	1,081	24	97.82
No. 4	21.52	1,711	17	99.01
No. 5	12.25	1,791	4	99.77
No. 6	8.00	1,170	10	99.15
Nos. 1 to 6 combined	96.79	9,224	63	99.32
Trees not sprayed:				
A	17.54	841	560	60.02
B	21.76	520	1,123	31.64
C	15.52	26	1,242	2.05
A, B, and C combined	54.82	1,387	2,925	32.16

Bitter-rot was not so severe on the Gano as it was on the Jonathan trees, but the crop on some of the unsprayed trees of the former variety was scarcely worth picking. As seen in Table 2, 99.32 per cent of the crop from 6 Gano trees was free from the disease, while only 32.16 per cent of sound fruit was obtained from the 3 checks.

TABLE 3.—*Comparison of sound and bitter-rot affected fruit from sprayed and unsprayed trees of the Ben Davis variety, Lincoln orchard, Bentonville, Ark., 1906. Fruit picked September 17.*

Date of spraying and tree number.	Yield.	Sound apples.	Diseased apples.	Percentage of sound fruit.
Trees sprayed July 10 and 23 and August 19:	*Bushels.*	*Number.*	*Number.*	
No. 1	18.73	2,101	27	98.73
No. 2	13.58	1,793	12	99.33
No. 3	6.36	825	30	96.37
No. 4	11.34	1,524	30	98.06
No. 5	4.00	541	2	99.63
No. 6	16.51	1,906	177	91.50
Nos. 1 to 6 combined	70.52	8,690	278	96.90
Trees not sprayed:				
A	2.60	18	801	2.19
B	9.64	92	1,456	5.94
C	11.88	169	1,416	10.66
A, B, and C combined	24.12	279	3,673	7.05

In Table 3 the results from the treatment of the Ben Bavis trees are given, the 6 sprayed trees yielding an average of 96.9 per cent of sound fruit and the 3 check trees only 7.05 per cent. Practically the entire crop of the unsprayed trees was lost, while the sprayed fruit suffered very little. This result is remarkably good for three applications, and such results can not be expected except after the most thorough work.

TABLE 4.—*Comparison of sound and bitter-rot affected fruit from sprayed and unsprayed trees of the Givens variety, Lincoln orchard, Bentonville, Ark., 1906. Fruit picked October 8 and 12.*

Date of spraying and tree number.	Yield.	Sound apples.	Diseased apples.	Percentage of sound fruit.
Trees sprayed July 10 and 23 and August 9 and 27:	*Bushels.*	*Number.*	*Number.*	
No. 1	19.86	2,341	111	95.43
No. 2	21.52	3,102	69	97.82
No. 3	23.00	2,659	10	99.62
No. 4	16.02	1,922	8	99.58
No. 5	21.26	2,017	7	99.65
No. 6	17.82	2,271	26	98.80
Nos. 1 to 6 combined	119.48	14,312	231	98.41
Trees not sprayed:				
A	4.75	3	2,266	.10
B	6.88	212	1,518	12.25
C	3.25	295	660	30.89
A, B, and C combined	14.88	510	4,444	10.29

The Givens, being a late-maturing variety, was not picked until October 8 and 12, two weeks later than the Ben Davis and six weeks later than the Jonathan. Therefore, in order to carry the crop through the season safely it was given an additional spraying on August 27. As seen in Table 4, the results were 98.41 per cent of sound fruit from the 6 sprayed trees and 10.29 per cent of sound fruit from the 3 unsprayed trees.

The above are four examples of almost complete protection against bitter-rot by the thorough application of Bordeaux mixture, and fully corroborate the results obtained in the experiments in the control of this disease conducted in Virginia in 1905. It would appear that there is no longer a reasonable excuse for the severe losses from this disease.

Cost of treatments.—In Captain Lincoln's orchard only 400 gallons of mixture were required for one spraying of 200 trees, and the work was accomplished with four men and one team in one-half day. The 40 pounds of bluestone at 8 cents a pound cost $3.20 and the same amount of lime at one-half cent a pound cost 20 cents. The four men, at $1.25 a day each, cost for the half day $2.50, and the team cost $1 for the half day. This aggregates $6.90 for spraying 200 trees, or a little less than 3½ cents a tree for one application. This makes a total cost of 10½ cents a tree for the three applications given to the Jonathan, Gano, and Ben Davis trees, and 14 cents a tree for the four applications that the Givens variety received. This is the cost of the bitter-rot treatment alone; if the cost of the arsenate of lead used for protection against the codling moth be included, 1⅓ cents per tree for each application should be added.

It will be seen from the tables that the sprayed trees averaged upward of 4 barrels to a tree, but being only 10 years old and well pruned they were easily sprayed and the cost of treatment was less than would be required for older trees.

RECOMMENDATIONS.

Although excellent results were obtained from three sprayings in the case of the Jonathan, Gano, and Ben Davis varieties, experience elsewhere has shown that it is not always safe to rely on so small a number of applications. The work here was done just at the right time, except the late beginning on the Jonathan, and with a thoroughness that is not ordinarily secured in general orchard spraying. The first application was made dangerously late, so that only two subsequent sprayings were required to cover the infection period. In the treatment of a larger orchard, requiring a week or more to cover it, such a late beginning might prove disastrous.

It is therefore recommended that four sprayings at intervals of two to three weeks, beginning about six weeks after the petals fall, be made where bitter-rot alone is to be treated. In order to get the fruit thoroughly covered with the spray before infection takes place the second application should follow the first within two weeks, while the intervals between the subsequent applications may be extended to three weeks unless the season be unusually wet and warm. Bordeaux mixture, made of 5 pounds of bluestone and 5 pounds of lime to 50 gallons of water, seems best for this disease, but the 4–6–50 formula[a] gives satisfactory results, especially where a larger number of applications are made for the combined treatment of bitter-rot and other troubles.

APPLE BLOTCH.

OCCURRENCE.

During the past several years the Department of Agriculture has received specimens of apples affected with a fungus (*Phyllosticta* sp.) causing blotches or spots, which so disfigure the fruit as to render it unmarketable. This disease has been variously known as "Phyllosticta," "black-scab," "late-scab," "cancer," and "fruit-blotch."

The records of the Department show that apples affected with this disease have been received from Virginia, Maryland, New Jersey, Ohio, Nebraska, Kansas, Missouri, Arkansas, Oklahoma, Indian Territory, and Texas. It has also been recorded from southern Illinois by Clinton.[b] Although appearing to have rather a wide distribution, it has not attracted much attention. This is perhaps due largely to the fact that, except in a few localities, it has not been a serious pest and has generally been mistaken by the orchardists for the ordinary apple scab. This proved to be the case in some of the orchards selected for demonstration spraying, and it turned out as the season progressed that this was one of the serious fungous troubles from which the orchardists were seeking relief.

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[a] Four pounds of bluestone and 6 pounds of lime to 50 gallons of water.

[b] University of Illinois Agric. Exp. Sta. Bul. 69, pp. 190–192, Pl. B, fig. 1.

DESTRUCTIVENESS.

The serious nature of apple blotch became apparent during the past season in southern Missouri and northwestern Arkansas, where 50 to 90 per cent of the apple crop was destroyed by it in a large number of orchards. During the month of September an examination of a dozen orchards in Benton County, Ark., showed the following estimated percentages of the crops affected by this disease:

Number of trees and percentage of affected fruit.

	Orchard number.											
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
Number of trees	800	1,000	2,000	4,000	1,000	1,500	1,500	500	500	25,000	500	1,000
Percentage of affected fruit	50	40	80	75	90	90	50	15	90	75	80	75

These orchards are located at widely separated points in the county, and the table fairly represents the conditions that obtained in unsprayed orchards throughout that section. Where the injury ran over 75 per cent of the crop no attempt was made to pick and barrel the fruit. It was usually shaken off and taken to the evaporators. Practically all of the fruit affected with this disease was unfit for barreling, but the larger percentage of it made good evaporator stock.

The season was unusually wet, which may account in part for this serious outbreak. According to the statements of a number of prominent apple growers of Arkansas, the disease has been a serious pest in that State for at least four years, but the severity of the outbreak during the past season is probably unusual.

DESCRIPTION.

The disease known as blotch first appears on the surface of the apple as a small irregular brown spot, which slowly increases in size until, after several weeks, it reaches one-fourth to one-half inch in diameter. Although the general outline of the spot is circular the margin is broken and fringed, with a radiating appearance, suggesting the name "blotch." (See fig. 2.) When the diseased area reaches about one-eighth to one-fourth inch in diameter several raised points (fruiting bodies) appear at and near the center. These points are dark brown at the apex, shading off into a light brown at the base. As the disease advances these bodies become more numerous, and although arranged somewhat in groups they are scattered rather promiscuously over the blotch. In some instances these bodies may uplift the skin of the apple in such a way as to form drab-colored blisters. The diseased area is rather superficial and slightly depressed and the epidermis becomes very hard.

Several blotches may occur on the same fruit, and in the Ozarks during the past season it was not uncommon to find 20 to 50 blotches on a single apple, covering practically the entire surface. The tissues of the invaded area being dwarfed by the action of the fungus, further growth of the apple results in a cracking of the fruit similar to that produced by the apple scab fungus. The cracks range from one-fourth to 1 inch in length and frequently extend almost to the center of the apple. In extreme cases a crack may almost encircle the apple, practically dividing it in half, and one crack may intersect another, forming a cross. Fruits only slightly affected with the disease may go through the season without developing cracks. These are more commonly developed shortly before the fruit matures, though a few may occur earlier in the season. The skin being thus broken, the fruit becomes an easy prey to other fungi and soon goes down in decay. As a rule the affected fruit drops prematurely, and the unsprayed Ben Davis trees left as checks in the demonstration blocks at Bentonville, Ark., shed 50 per cent of their crop some days before picking time.

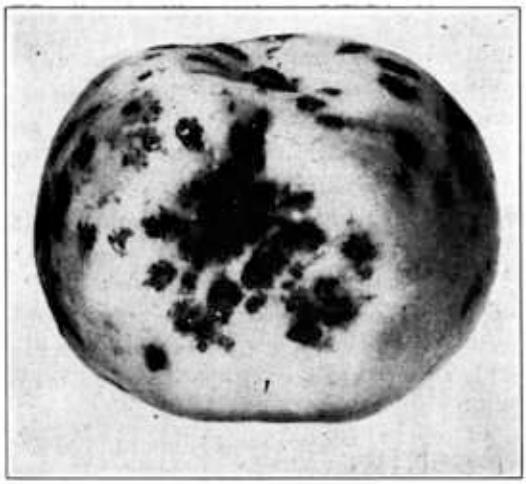

FIG. 2.—A Maiden Blush apple affected with apple blotch. (Original.)

PERIOD OF INFECTION.

Infection does not begin to take place until the fruit is nearly half grown. The blotch was first observed on the check trees June 26, and only a few affected fruits could be found on that date. On July 16 a large percentage of the Ben Davis apples was affected, and by the middle of August it was clearly seen that the crop was practically lost. It developed first on fruit on the lower branches and within the shaded portions of the tree, but finally spread to almost the entire crop.

THE CAUSE.

Apple blotch appears to be the same disease as that described from Illinois by Clinton[a] as due to an undescribed fungus, belonging to the genus *Phyllosticta*. This fungus is under investigation by Messrs. Rorer and Scott, of the Bureau of Plant Industry, who expect to report on it at the end of another season.

[a] University of Illinois Agric. Exp. Sta. Bul. 69, pp. 190–192, Pl. B, fig. 1.

The treatment.—As stated above, the apple blotch appeared to a disastrous extent in some of the demonstration blocks. Excellent opportunities were, therefore, afforded for observing the effect of spraying with Bordeaux mixture in the control of this disease in connection with the spraying in the Gipple orchard at Bentonville, Ark. One hundred Ben Davis trees, 18 years old, fairly vigorous and in good condition, were used, of which number 24 trees were set aside as checks and left untreated. A block of 100 Winesap trees was also used in the demonstration work, but as the apple blotch did not develop to a serious extent on this variety, only the results obtained on the Ben Davis block will be reported here.

The trees were sprayed with Bordeaux mixture on May 4 (about four days after the petals had fallen), May 8, June 12, June 26, July 17, and August 4, making six applications in all. This orchard was reached late, and the two early applications were made only four days apart in order to thoroughly poison the fruit for the codling moth before the calyx lobes closed, and for protection against apple scab. The formula of Bordeaux mixture used was 4 pounds of bluestone and 6 pounds of lime, with the addition of 2 pounds of arsenate of lead, to 50 gallons of water.

The results.—The crop was picked from September 19 to 27, and the fruit from each of the several sprayed and unsprayed trees was classified according to injury from scab, apple blotch, bitter-rot, black-rot, and the codling moth, the affected apples being counted in each case. The crop from the remaining trees, sprayed and unsprayed, was simply classified as merchantable and unmerchantable fruit, as shown later (p. 33). The windfalls were included in the counts, so that practically every apple produced by the trees was taken into account. The first count of windfalls was made on August 4 in order to get their classification before they decayed, and the fruit that fell subsequently was classified at the time the crop was harvested.

The results of the treatments in controlling the apple blotch are shown in Table 5.

TABLE 5.—*Comparison of sound fruit and fruit affected with apple blotch from 3 sprayed and 3 unsprayed Ben Davis trees, Gipple orchard, Bentonville, Ark., 1906. Fruit picked September 19 to 27.*

	Trees sprayed May 4, 8, June 12, 26, July 17, and August 4.				Trees not sprayed.			
	No. 1.	No. 2.	No. 3.	Nos. 1 to 3 combined.	A.	B.	C.	A, B, and C combined.
Total bushels	17.0	18.3	19.5	54.8	14.5	5.85	3.19	23.54
Number of sound apples	2,145	2,617	2,649	7,411	872	226	72	1,170
Number of diseased apples	140	320	254	714	1,887	853	568	3,308
Percentage of sound fruit	93.87	89.1	91.25	91.21	31.60	20.94	11.25	26.12

As shown in Table 5, about 90 per cent of the crop from the sprayed trees remained free from the apple-blotch disease, while about 75 per cent of the crop of the unsprayed trees was destroyed by it. This fairly represents the conditions as they existed throughout the block, as shown by the comparative commercial yield of the sprayed and unsprayed trees given later (p. 33). It will be noted, however, that in spite of the spraying nearly 10 per cent of the crop was affected, but the diseased spots were, as a rule, very small, and in many cases scarcely noticeable. They were mainly on apples that were on low-hanging branches, well in toward the trunk and protected from the spray by the outer branches. In cases where only one side of an apple was reached by the spray, owing to some obstruction, the spots developed on the unsprayed side. This emphasizes the importance of driving the mixture into all parts of the tree in order to spray every apple thoroughly. Since the period of infection is about the same as that of bitter-rot, it appears that the same treatment is applicable to both diseases. In connection with some bitter-rot experiments conducted in the same orchard, it developed that the early applications were not necessary for the control of apple blotch. In fact, trees that were sprayed May 4, May 8, June 12, and June 27 had 46.6 per cent of the crop affected with apple blotch, showing that these applications gave only slight protection against this disease.

RECOMMENDATIONS.

Make four applications of Bordeaux mixture at intervals of two weeks, beginning about six weeks after the petals fall. This corresponds exactly with the treatment for bitter-rot, and the two diseases may, therefore, be controlled with the same applications. However, as apple blotch seems rather more difficult to control than bitter-rot, in sections where severe outbreaks occur treatment should perhaps begin a week earlier and be continued later, making five applications in all. So far as the writers know, these are the first experiments in which this disease, when occurring on the fruit, has been successfully controlled.

LEAF-SPOT DISEASES.

There are several species of fungi that attack apple leaves, producing brown, circular spots that range from mere specks to spots one-fourth of an inch in diameter and in some cases much larger, as shown in figure 3. The disease may begin to appear in the spring soon after the young leaves unfold, but the spots are usually more prominent between midsummer and the end of the season. This diseased condition causes the leaves to drop prematurely, frequently leaving the trees denuded in early autumn, six weeks or two months before the

normal period of leaf fall. Trees thus deprived of their foliage cease activity, and as a result the fruit is small and not properly matured; the buds for the crop of the following year are weakened and in some cases not fully developed, and the life of the tree is materially shortened. These leaf diseases are partly responsible for the failure of the trees to produce crops and for the early decline of the orchard.

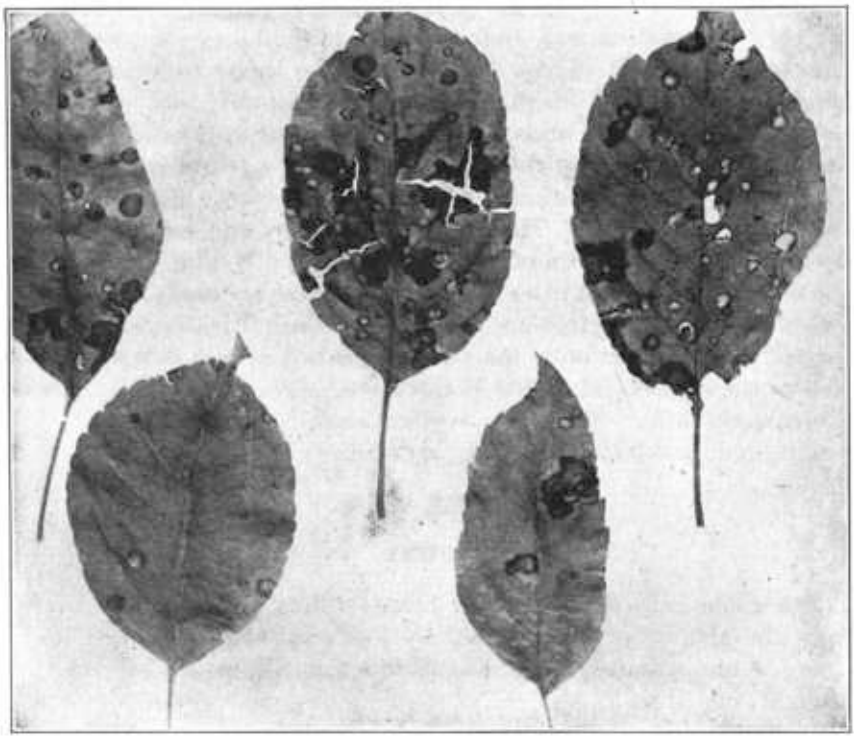

FIG. 3.—Apple leaves affected with leaf-spot diseases. (Original.)

THE CAUSE.

Leaf spots are due to several different fungi, perhaps the most prominent of which is a species of Phyllosticta. A species of Hendersonia and the ordinary black-rot fungus, *Sphæropsis malorum*, are found in connection with some of these spots and may be responsible for the injury in some cases. Other fungi are also frequently present in the dead areas, and it is not always clear which are the real parasites.

RESULTS OF TREATMENT.

One of the most striking results of spraying an apple orchard is the effect on the foliage. These leaf diseases are largely prevented by applications of Bordeaux mixture, and the foliage remains fresh and

green long after unsprayed trees are defoliated. This was true of all the demonstration blocks in the Ozarks during the past season. The unsprayed trees began to shed their leaves in July and were practically defoliated by the last of August, a month before the time to pick the crop.

RECOMMENDATIONS.

The treatment recommended for bitter-rot and apple blotch will largely prevent these leaf troubles and hold the foliage in good condition until frost. It is true that some of the leaves become affected soon after they unfold in the spring, but the trouble does not usually become serious before midsummer, and the four applications of Bordeaux mixture for bitter-rot at intervals of two to three weeks, beginning about six weeks after the blossoms are shed, appear to give reasonable protection. However, the earlier applications usually necessary for the control of apple scab and the codling moth aid in the control of leaf-spot diseases, and when these are made, only one or two of the later sprayings are necessary. When it is desired to spray for leaf-spot diseases only, the first application should be made about two or three weeks after the petals have fallen, and a second about seven weeks later. These two applications, if thoroughly made, will usually hold the foliage in good condition.

APPLE SCAB.

INJURY.

The apple crop of the United States suffers a greater loss by far from the attacks of scab, caused by *Venturia inæqualis* (Cke.) Ader, than from any other fungous disease to which this fruit is subject. It often affects 50 to 75 per cent of the crop over wide areas, and is not infrequently responsible for total failures by killing the young fruits when in blossom or soon thereafter, and by rendering the fruit too unsightly for the market.

Scab has a wide distribution, being exceedingly serious in New England, the Middle Atlantic States, the Mississippi and Ohio valleys, and the Pacific Northwest. In these regions it is almost impossible to obtain crops reasonably free from scab without spraying. Indeed, so great is the damage done by this fungus and the codling moth that the percentage of strictly first-class fruit placed on the market is quite small, the great bulk of the crop, as a rule, being only second class.

DESCRIPTION.

The scabby spots that appear on the fruit are so familiar to apple growers that a description here is almost superfluous. They are circular, rough, somewhat irregular in outline, grayish or olive-green

in color, becoming black when older, and range in size from mere specks to spots one-fourth to one-half inch in diameter. Two or more spots may coalesce, forming large, irregular scabby areas. The ruptured skin of the apple usually persists around the margin of the spot, leaving a light-colored ring at the border of the healthy tissue.

Young fruits affected with this disease may become pitted, one-sided, and otherwise distorted, and in severe cases the fruit becomes cracked, as shown in figure 4. The fungus may attack and destroy the blossoms and even the unopened buds; the flower stalks may become so weakened by the disease that the young fruit drops off. The disease also appears on both sides of the leaves and on the leaf-stalks in the form of smoky brown patches, which become swollen and blister-like. It often causes the leaves to curl more or less and results in the premature shedding of the foliage. The scab first appears early in the spring on the young buds and unfolding leaves, and new infections may continue to take place throughout the season.

FIG. 4.—Apples badly affected with scab. (Original.)

THE CAUSE.

Apple scab is due to the presence of the fungus *Venturia inæqualis* (Cke.) Ader, which grows beneath the cuticle of the leaves and fruit, invading the superficial cells with its branching threads. In a short time the fungus gives rise to groups of small stalks, which break through the cuticle, or skin, and give forth numerous minute olive-colored spores. These spores are blown about by the wind, and it is by means of these wind-dispersed spores that the infection takes place. The fungus is carried over winter in the diseased leaves on the ground, where spores of the perfect stage are produced, which are discharged in early spring as the young leaves and fruit buds begin to open. These winter spores start the infection, which is further spread by the summer spores, soon produced by the new scab spots.

RESULTS OF TREATMENT.

The treatment for apple scab has been known for a number of years. It was worked out fully by the Bureau of Plant Industry in 1891–1893 in experiments carried on in the State of New York. Certain progressive apple growers have known that thorough applications of Bordeaux mixture just before the trees bloom, and again as soon as the petals have fallen, will largely prevent this disease.

The scab was not serious in the Ozark region during the past season, and unsprayed trees showed but slight infections. On this account the results from spraying in the demonstration orchards are not considered of sufficient importance to present here. It may be worth while, however, to give some results in controlling scab obtained in the orchard of the Morton estate at Nebraska City, Nebr., in connection with a spraying experiment conducted by the Department of Agriculture during the past season, devoted to codling moth as well as scab.

There were 13 different plots of 6 trees each and 12 checks, but only plots 1 and 2 and the checks will be here considered, as these other plots were devoted primarily to the codling moth or were planned to show the danger of omitting treatment at critical periods. Plot 1 was sprayed first when the cluster buds were open, shortly before blooming (April 25), and again as soon as the petals had fallen (May 11). Plot 2 had the same applications and a third spraying on May 17. The 5–5–50 formula of Bordeaux mixture was used for the first application, and the 4–6–50 formula with 2 pounds of arsenate of lead for the succeeding applications. The results from 3 trees of each sprayed plot and 3 untreated trees are given in Table 6:

TABLE 6.—*Comparison of sound and scabby fruit from sprayed and unsprayed winesap trees, Morton orchard, Nebraska City, Nebr., 1906. Fruit picked Oct. 20.*

Tree.	Total quantity.	Sound apples.	Diseased apples.	Percentage of sound fruit.
Plot I:[a]	*Bushels.*	*Number.*	*Number.*	
No. 1	22	5,157	145	97.26
No. 2	18	4,591	128	97.28
No. 3	13.5	3,345	33	99.02
Nos. 1, 2, and 3 combined	53.5	13,093	306	97.71
Plot II:[b]				
No. 1	18	4,607	46	99.01
No. 2	15	4 256	11	99.74
No. 3	14	4,057	51	98.78
Nos. 1, 2, and 3 combined	47	12,920	108	99.17
Check:[c]				
No. 1	11	971	1,949	33.25
No. 2	12	1,297	1,890	40.69
No. 3	16	1,309	2,626	33.26
Nos. 1, 2, and 3 combined	39	3,577	6,465	35.62

[a] Sprayed April 25, when cluster buds opened; May 11, as petals fell.
[b] Sprayed April 25, when cluster buds opened; May 11, as petals fell; May 17, six days after petals fell.
[c] Unsprayed.

As has been abundantly demonstrated in the past, these results again show that apple scab can be readily controlled by applications of Bordeaux mixture. It is seen in Table 6 that Plot I, which had two applications, yielded 97.71 per cent of sound fruit, and that Plot II, which received three applications, gave 99.17 per cent of sound fruit. In this case the third application was of very little additional benefit; but if the second spraying is not thoroughly done a supplemental treatment a few days later is quite important. It should be understood, however, that these results, obtained from two or three sprayings, apply only west of the Missouri River. In the more humid sections to the eastward, especially around the Great Lakes, in a wet spring 5 or 6 treatments are necessary.

RECOMMENDATIONS.

Spray with Bordeaux mixture, 5–5–50 formula, when the cluster buds are open but before blooming, and again as soon as the petals have fallen. If the second application has not been very thorough, a third should be made seven to ten days later. In case of a wet spring three sprayings are usually necessary.

THE CODLING MOTH.

The larva of the so-called codling moth (*Carpocapsa pomonella* L.) is by far the most serious of the insect pests which affect the apple. The losses due to its work equal if they do not exceed the losses from all other insect pests of this crop combined. In unsprayed orchards throughout the country from one-half to three-fourths of the crop is destroyed, entailing a loss of millions of dollars annually. A large percentage of this loss is preventable, as has been known for many years, and a large number of orchardists practically control the insect by timely and thorough work with sprays. Indeed, the codling moth is perhaps more satisfactorily controlled than most other insect pests of the apple, such as apple-tree borers, the apple maggot, the plum curculio, scale insects, and the wooly apple aphis. Notwithstanding the large amount of testimony from experimenters and practical orchardists as to the advantages of spraying, there are yet many growers who take no steps to control the pest or who secure only indifferent results from lack of knowledge of the insect itself and of the requisites for successful control work.

CHARACTER OF INJURY.

Wormy apples (see fig. 5) are familiar to all growers and consumers of this fruit, and many have seen, upon cutting open an apple, the small, pinkish larva, about three-fourths of an inch long, the cause of all the mischief. The greater part of the life of the larva is spent

within the fruit, during which period it feeds freely on the substance of the apple, eating out a cavity or tunnel and pushing out from the entrance hole a considerable quantity of powdery brown frass. Most apples injured when small, as by larvæ of the first generation, drop from the trees, and these often constitute a large percentage of the so-called windfalls. Larvæ of the first generation will mostly enter the fruit at the blossom end, some, however, entering at the side, as where two fruits are in contact or where an apple is touched by a leaf. Larvæ of the second generation enter the fruit more from the side than the calyx end, and by reason of their greatly increased numbers cause the larger part of the total injury. In localities where a third or partial third brood may occur, the habits of this generation are no doubt practically identical to those of the second.

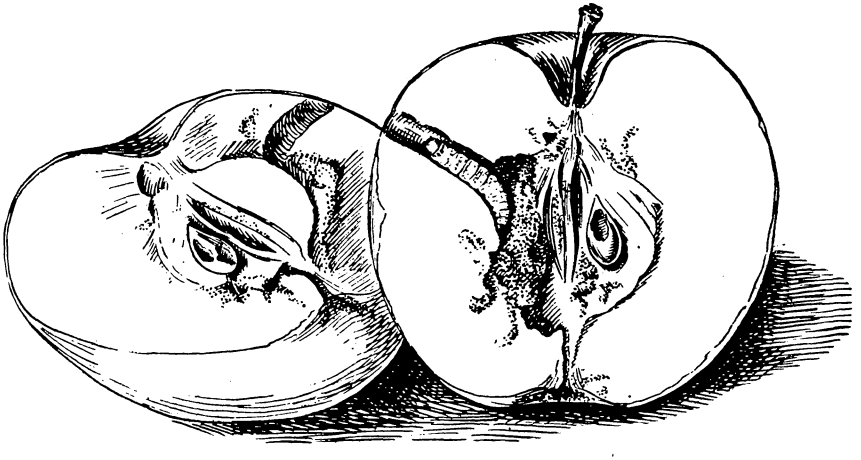

FIG. 5.—A wormy apple, showing a mature codling moth larva and its work. (Original.)

DESCRIPTION AND LIFE HISTORY.

How the insect passes the winter.—In late summer or fall larvæ seek protected places upon the trees, as holes, cracks, crotches of limbs, or under bark scales, or even underneath trash on the ground, construct tough silken cocoons, and here pass the winter in the larval condition. Large numbers of larvæ are carried to storage houses in apples in the fall, where later they spin cocoons in the boxes, bins, or barrels, or in cracks in the floor or sides of the house. In the orchard large numbers of larvæ are destroyed during winter by birds, principally woodpeckers, but in storage houses a large proportion doubtless survives, the moths from which fly to the orchards in the spring and constitute an important source of infestation.

With the coming of spring the larvæ enter the pupal stage, and later, about the period of blooming of the apple, the moths begin to

appear, continuing to emerge for three or four weeks, while belated moths may not emerge until considerably later.

The moth.—The adult, or miller, (fig. 6, *a*, *f*) is rather variable in size, but the maximum wing expanse rarely exceeds three-fourths of an inch. The forewings above are of a brownish gray color, with numerous cross lines of gray. Near the tip of each wing is a conspicuous brown spot, or ocellus, in which are two irregular broken lines of a metallic coppery or golden color. The hind wings above are grayish brown, becoming darker toward the margin, which bears a delicate fringe, at the base of which is a narrow dark line. When at rest on the grayish bark of an apple tree, the color of the moth so harmonizes with its surroundings that it is not readily distinguished, and the insect in this stage is perhaps but little known to orchardists.

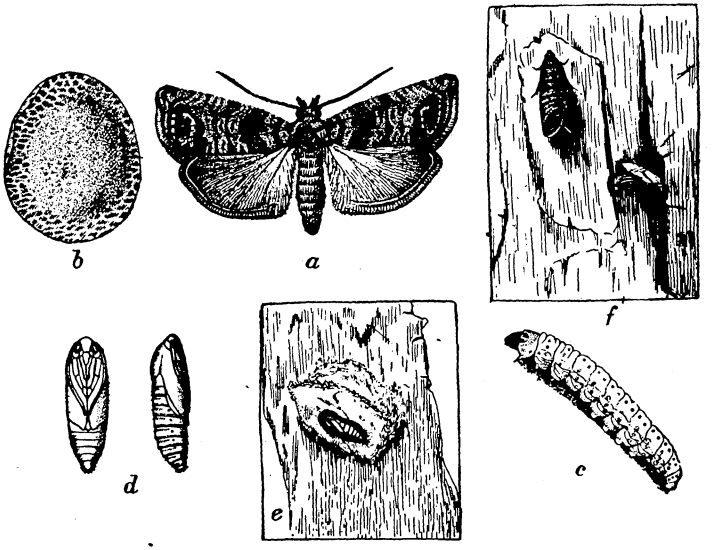

FIG. 6.—Stages of the codling moth: *a*, the moth or adult insect, slightly enlarged; *b*, the egg, greatly enlarged; *c*, the full-grown larva, slightly enlarged; *d*, the pupa, slightly enlarged; *e*, the pupa in its cocoon on the inner surface of a piece of bark, reduced about one-half; *f*, moth on bark and empty pupa skin from which it emerged, about natural size. (From Simpson.)

Shortly after emerging (fig. 6, *f*), the sexes mate and the females begin the deposition of eggs, the number for one individual, as stated in the literature regarding this insect, averaging about 50.

The egg.—The eggs are small, flat, somewhat oval in shape, of about the size of a pinhead. When recently deposited they are of a pearl-white color, but become darker with the development of the embryo, which after a few days is easily distinguished as a reddish ring within the egg. Under a lens the surface is seen to be covered with a network of ridges (fig. 6, *b*), coarser toward the edge. The eggs of the first generation of moths are deposited mainly on the leaves

and twigs, comparatively few being placed on the apple, possibly on account of the fine hairs with which it may be more or less covered when small. The majority of the eggs of the second generation, however, are placed on the fruit, which by this time is much larger and presents a comparatively smooth surface. The average time required for the egg to hatch is about eleven days, the time varying considerably, however, with temperature.

The larva.—It is in the larval or "worm" stage that injury is done to the apple. The larva as it hatches from the egg is very small, from one-twentieth to one-sixteenth of an inch in length, and soon begins to search for the fruit. If hatched from eggs placed here and there on the foliage, the larvæ chew more or less into the leaf or other portions of the plant in their wandering around, and may thus be poisoned if poison be present on the plants. If the eggs have been deposited on the fruit itself the larvæ are much more likely to gain entrance to the fruit. Larvæ entering the fruit by the calyx end feed within the calyx cavity for a few days before penetrating the fruit, and hence the advantage of thoroughly spraying trees shortly after the petals have fallen and while the calyx lobes are still spread, in order to place in each calyx cavity a small particle of poison to be later eaten by the little larva as it seeks to enter the fruit.

After entering the apple the larva feeds and grows rapidly and in the course of about twenty days has become full grown. At this time the insects are about three-fourths of an inch long, and the majority of them are pinkish or flesh colored on the upper surface and whitish below. The head is brown and well developed, and there are 8 pairs of legs, the 3 pairs of true legs on the thorax and 5 pairs of prolegs on the abdomen (fig. 6, *c*).

When ready to leave the fruit the larva eats out a hole at the side, or, less usually, makes its exit by enlarging the entrance hole. If the infested apple is hanging on the tree the larva usually makes its way out to the limb and thence crawls down the branches to the trunk until a suitable place for pupation is found. If the apple has fallen before the larva has gotten its growth the latter simply crawls to a convenient place and there constructs a cocoon.

The pupa.—The full-grown larva, upon leaving the fruit and finding a protected place, constructs a whitish silken cocoon (fig. 6, *e*) within which in the course of a few days it may change to pupa or may remain in the larval condition until the following spring, as explained under the next heading. The pupa (fig. 6, *d*) is about one-half inch long, at first yellowish or brownish, but later becoming quite dark brown, and shortly before the emergence of the moth assuming a distinct bronze color. This stage varies much in length, but on the average about twenty days elapse from the spinning of the cocoon

until the emergence of the moth. After emergence the moths in the course of a few days begin egg laying, the entire life cycle from egg to egg requiring, on the average, some fifty days.

GENERATIONS OF THE INSECT.

The number of generations of the codling moth in a season varies with the latitude and region. In the more Northern States, as in Maine and New York, there is but one generation each year, with often a rather light partial second, the size of the second generation varying with the season. In the upper tiers of Middle Eastern and Western States, as New Jersey, Ohio, and Iowa, the second generation will be more nearly a full one. In States of the latitude of Virginia, Kentucky, Kansas, and Colorado there will be two full generations, while in the extreme South and Southwest and portions of the West a partial third generation is thought to occur. Injury from the second brood is much greater than from the first and, unfortunately, more difficult to prevent.

As stated, moths of the first or overwintering generation will begin to emerge about the time apple trees are in bloom, continuing for some weeks, the date varying according to locality and season. The moths of the second generation may begin to appear fifty to sixty days from the blooming period, though their maximum abundance will be somewhat later. The first and second generations will overlap, so that larvæ are to be found in the fruit practically throughout the season. In the Ozarks, moths of the second generation are coming out in some numbers by about July 15, the number increasing throughout late July and early August.

DEMONSTRATION SPRAYING FOR THE CODLING MOTH.

In spraying with Bordeaux mixture for the fungous diseases of the apple previously mentioned, an arsenical was always added for the control of the codling moth. In securing results the drop apples were collected from the ground and examined as to freedom from or injury by the codling moth, and the crop from the trees at picking time was similarly graded. In some cases the fruit was simply measured; in others it was actually counted.

Results in Arkansas.—In the Gipple orchard at Bentonville four trees in the Ben Davis block sprayed for bitter-rot and apple blotch were selected for obtaining data on the effect of the treatments for the codling moth. The arsenical used was arsenate of lead at the rate of 2 pounds to 50 gallons of Bordeaux mixture, and applications were made on May 4, May 8, June 12, June 26, July 16, and August 4, making six treatments in all. The first two applications, on May 4 and May 8, immediately after the petals had fallen—perhaps the

most important of all treatments—were far from satisfactory, efficient spraying apparatus not then being available. Subsequent applications, however, were quite thorough, and the trees and fruit were kept fairly well coated with the spray during the remainder of the season. The orchard under experiment, however, was joined on two sides by orchards which were not sprayed and which served as sources of reinfestation, the moths undoubtedly flying into the treated orchard from the untreated ones. Injury from the second brood of the codling moth was therefore greater than would probably have been the case had the adjacent orchards received proper treatment.

The fruit from four untreated trees in the bitter-rot check was also classified in regard to codling moth injury, to serve as a basis for comparison with the sprayed trees. The yield of sound and wormy fruit from the eight trees is detailed in Table 7.

TABLE 7.—*Comparison of sound and wormy fruit from four Ben Davis trees sprayed with Bordeaux mixture and arsenate of lead and from four unsprayed trees, Gipple orchard, Bentonville, Ark., 1906. Fruit picked September 19 to 27.*

Date of spraying and tree numbers.	Total crop.	Windfalls.			Fruit from tree.			Total number of apples.	Percentage of sound fruit.
		Wormy.	Not wormy.	Total.	Wormy.	Not wormy.	Total.		
Sprayed May 4, May 8, June 12, June 26, July 16, and Aug. 4:	*Bushels*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	
Tree 1	17	41	86	127	108	2,050	2,158	2,285	93.5
Tree 2	13.1	82	167	249	117	1,433	1,551	1,800	88.8
Tree 3	19.56	167	337	504	270	2,129	2,599	2,903	84.9
Tree 4	18.33	143	244	387	215	2,335	2,550	2,937	87.8
Trees 1 to 4 combined	67.99	433	834	1,267	710	7,947	8,858	9,925	88.4
Unsprayed:									
Check A	14.5	799	454	1,253	906	595	1,501	2,754	38.8
Check B	5.59	195	97	292	421	342	763	1,055	41.6
Check C	3.19	200	120	320	224	96	320	640	33.7
Check D	5.85	336	139	475	371	233	604	1,079	34.4
A, B, C, and D combined	29.13	1,530	810	2,340	1,922	1,266	3,188	5,528	37.5

It will be seen that the average percentage of sound fruit from the four sprayed trees is 88.4, and from the four unsprayed trees 37.5, a gain in fruit free from codling moth injury of 50.9 per cent.

Results in Missouri.—Demonstration work at Fordland, Mo., was carried out in the orchard of Mr. J. E. Hansell, in a block of trees from 10 to 12 years old, including the Gano, Jonathan, and Ben Davis varieties.

Gano.—Plot 1, of 14 trees, was sprayed with Bordeaux mixture and arsenate of lead at the rate of 2 pounds to 50 gallons.

Plot 2, of 16 trees, was sprayed with Bordeaux mixture and Paris green at the rate of 1 pound to 150 gallons.

A block of 15 trees was left untreated as a check.

Applications were made on the following dates: April 20, May 7, May 16, June 8, June 26, July 17, and August 11, making a total of seven, of which, however, only six are to be considered as in any way affecting the codling moth, the treatment on April 20 being for scab and before the trees had bloomed.

The second application was made just after the petals fell from the blossoms and the third nine days later. These two, made while the calyx lobes of the young apples were still spread, were for the purpose of filling the calyx cavities with poison, and they were also important treatments for the apple scab.

The fourth application, on June 8, was designed especially to poison the foliage and fruit to destroy the codling moth larvæ, which it was thought would be hatching in considerable numbers at about that time.

The three subsequent applications were for the control of bitter-rot, leaf-blight, and the second brood of the codling moth. The results are shown in Table 8.

TABLE 8.—*Comparison of sound and wormy fruit from Gano trees sprayed and unsprayed, Hansell orchard, Fordland, Mo., 1906.*

Plot, date of spraying, and tree number.	Total crop.	Windfalls.			Fruit from tree.			Per-centage of sound fruit.
		Wormy.	Not wormy.	Total.	Wormy.	Not wormy.	Total.	
Plot 1, sprayed April 20; May 7, 16; June 8, 26; July 16; August 11:	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	
Tree 1	11.76	[a] 0.017	0.5	0.51	0.25	11	11.25	97.7
Tree 2	5.81	[b] .005	.25	.255	[c] .055	5.5	5.555	98.9
Trees 1 and 2 combined	17.57	.022	.75	.765	.305	16.5	16.805	98.1
Plot 2, sprayed April 20; May 7, 16; June 18, 26; July 17; August 11:								
Tree 1	13.419	.044	.75	.794	.125	12.5	12.625	98.7
Tree 2	6.464	0	.42	.42	.044	6	6.044	97.7
Trees 1 and 2 combined	19.88	.044	1.17	1.21	.169	18.5	18.669	98.4
Check plot, unsprayed:								
Tree 1	5.045	.42	.125	.545	2	2.5	4.5	52.03
Tree 2	10.875	.75	.5	1.25	4.125	5.5	9.625	55.17
Trees 1 and 2 combined	15.92	1.17	.625	1.795	6.125	8	14.125	54.1

[a] 3 apples. [b] 1 apple. [c] 10 apples.

The average yield of sound fruit of the two trees of Plot 1 which received Bordeaux mixture and arsenate of lead is 98.1 per cent, and from the two trees of Plot 2, treated with Bordeaux mixture and Paris green, 98.4 per cent. The average yield of sound fruit from the two untreated trees is 54.1 per cent, there being a gain in sound fruit from the sprayed trees of 44 per cent.

Ben Davis.—In each of Plots 1 and 2 of the Gano block, and in an additional plot (Plot 3) were a few trees of the Ben Davis variety

which were sprayed along with the Gano, as previously stated. Plot 3 received the same treatment as Plot 2, except that the application on June 8 was omitted. The fruit from one Ben Davis tree of each of these plots, as well as from three unsprayed Ben Davis trees, was examined and classified by counting with respect to codling moth injury, and the results are detailed in table 9.

TABLE 9.—*Comparison of sound and wormy fruit from three trees sprayed with Bordeaux mixture and arsenicals, and from three unsprayed trees of the Ben Davis variety, Hansell orchard, Fordland, Mo., 1906.*

Date of spraying and tree number.	Total yield.	Windfalls.			Fruit from tree.			Total number of apples.	Percentage of sound fruit.
		Wormy.	Not wormy	Total.	Wormy.	Not wormy.	Total.		
Sprayed Apr. 20; May 7, 16; June 8, 26; July 17, and Aug. 11:	*Bush.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	
Tree 1	14	20	168	188	153	1,754	1,907	2,095	91.7
Tree 2	13.25	11	91	102	129	1,605	1,734	1,836	92.3
Tree 3[a]	13.75	26	52	78	206	1,562	1,768	1,846	87.4
Trees 1, 2, and 3 combined	41	57	311	368	488	4,921	5,409	5,777	90.5
Unsprayed:									
Check 1	11.75	464	38	502	1,258	383	1,641	2,143	19.6
Check 2	6.875	224	24	248	697	488	1,185	1,433	35.7
Check 3	5.50	315	89	404	564	428	992	1,396	37.0
Trees 1, 2, and 3 combined	24.125	1,003	151	1,154	2,519	1,299	3,818	4,972	29.1

[a] Treatment on June 8 omitted.

The three sprayed trees show an average percentage of sound fruit of 90.5 as against 29.1 per cent, the average percentage of sound fruit from the three unsprayed trees. This is a gain of 61.4 per cent for the treated trees.

Jonathan.—In a block of about 400 Jonathan trees used in some spraying experiments in the Hansell orchard at Fordland were three plots comprising 49 trees which received the demonstration treatment. These were sprayed with Bordeaux mixture and Paris green, 1 pound to 150 gallons, on the following dates: April 19, May 3, May 12, June 7, June 26, July 17, and August 11. The first application, April 19, for scab, was without effect in controlling the codling moth. Near each end of the block of 400 trees two adjacent rows were left untreated as checks, comprising in all 70 trees. The trees in this block are about 11 years old and small for their age. The orchard had had but little attention since 1901, and the crop of fruit was very light.

The effect of the treatments in controlling the codling moth is shown by the figures from 6 sprayed and 6 unsprayed trees presented in Table 10.

TABLE 10.—*Comparison of sound and wormy fruit from trees sprayed with Bordeaux mixture and Paris green, and from six unsprayed trees of the Jonathan variety, Hansell orchard, Fordland, Mo., 1906.*

Date of spraying and tree number.	Total yield.	Windfalls.			Fruit from tree.			Percentage of sound fruit.
		Wormy.	Not wormy.	Total.	Wormy.	Not wormy.	Total.	
Sprayed Apr. 29; May 3, 12; June 7, 26; July 17; Aug. 11:	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*
Tree 1	4.37	[a] 0.02	0.25	0.27	0.10	4	4.10	97.2
Tree 2	2.24	0	.12	.12	.12	2	2.12	94.6
Tree 3	3.96	[b] .01	.37	.38	.08	3.5	3.58	97.7
Tree 4	1.77	0	.25	.25	.02	1.5	1.52	98.8
Tree 5	3.27	[c] .03	.37	.40	.25	2.62	2.87	91.1
Tree 6	6.14	[d] .02	.37	.62	.25	5.5	5.75	95.6
Trees 1 to 6 combined	21.75	.08	1.73	2.04	.82	19.12	19.94	95.8
Unsprayed:								
Tree 1	4.62	.25	.87	1.12	1.5	2	3.5	62.1
Tree 2	.99	.12	.12	.24	.25	.5	.75	62.6
Tree 3	4.48	.62	.37	.99	1.12	2.37	3.49	61.1
Tree 4	4.62	.5	.25	.75	.62	3.25	3.87	75.7
Tree 5	2.86	.62	.12	.74	.62	1.5	2.12	56.6
Tree 6	4.25	1	.25	1.25	.75	2.25	3	58.8
Trees 1 to 6 combined	21.82	3.11	1.98	5.09	4.86	11.87	16.73	63.4

[a] 5 apples. [b] 3 apples. [c] 8 apples. [d] 6 apples.

It will be seen that the average yield of fruit free from codling moth injury from the 6 sprayed trees was 95.8 per cent as against 63.4 per cent of uninjured fruit from the 6 unsprayed trees, being a gain of 32.4 per cent.

It will have been noticed that in the work in Fordland, Mo., the percentage of codling moth injury to fruit from the treated trees was appreciably less than in the work at Bentonville, Ark. As explained in regard to the treated orchard at the latter place, this was bordered on two sides by large orchards which received no treatment during the season and which without doubt served as sources of reinfestation for the treated trees. The orchard at Fordland, on the other hand, was isolated, except for one orchard bordering it on the north, which received treatment for the codling moth.

The codling moth is best controlled when all of the orchards of a neighborhood are sprayed, and uniformity in this particular on the part of orchardists should be secured if possible.

RECOMMENDATIONS.

The first treatment for the codling moth should be made immediately after the blossoms fall. In this application the aim should be to place, as nearly as possible, a particle of the poisoned spray in the calyx cavity of every apple. At this time the little apples are mostly upright on the stems, and more effective work may be done by spraying from above, directing the spray downward. Long extension rods are indispensable, and for this application an elbow fitting between

the end of the rod and nozzle to better deflect the spray may often be used with advantage, or the chamber portion of the nozzle may be turned so that the spray will be directed at a right angle to the axis of the extension rod. One man at least, who should give special attention to treating the higher parts of the trees, should be on an elevated platform rigged upon the spray wagon. This is without doubt the most important of all of the applications for the codling moth, and some growers find it profitable to respray the trees at once after the first application has been finished and before the calyx lobes close, to further insure that the calyx end of each apple shall contain a particle of poison.

The second application for the codling moth should be made about three or four weeks from the dropping of the blossoms. The eggs of the first brood are hatching about this time in maximum numbers, and as they are mostly deposited on the foliage and twigs the resulting larvæ will feed more or less on these parts before gaining entrance to the fruit. Thorough spraying of foliage and fruit at this time will undoubtedly destroy many of these larvæ. If the first and second treatments have been thoroughly made, subsequent treatments are sometimes not necessary, especially if there is no danger of reinfestation from outside unsprayed orchards.

The first and second treatments may always be combined with the applications of Bordeaux mixture for apple scab. Where spraying with Bordeaux mixture is done for leaf-spot diseases, apple blotch, or bitter-rot, arsenicals should always be added for the second brood of the codling moth, and where injury from the first brood has not been satisfactorily prevented it will pay to spray for the second brood of the moth, irrespective of other considerations.

The third treatment for the codling moth (first treatment for second brood) should be made in ten weeks from the falling of the blossoms, and a fourth application should be given two or three weeks later.

COMMERCIAL RESULTS.

RESULTS IN ARKANSAS.

In addition to showing the effect of the treatments in controlling the respective diseases and the codling moth, as detailed in the foregoing pages, the fruit from a considerably larger number of trees in each of the demonstration orchards was classified into marketable fruits and culls, the culls including all fruit showing damage from the affections under consideration, all windfalls, and perfect fruit too small or too green for packing.

In the Gipple orchard at Bentonville, the crop from 47 trees of the sprayed block of Ben Davis trees was picked and classified on the sorting table, yielding the following results:

Merchantable fruit	bushels..	408
Culls (including windfalls)	do....	98.75
Percentage of merchantable fruit		80.5

The crop from 17 untreated Ben Davis trees in the same block was similarly sorted, and gave results as follows:

Merchantable fruit	bushels..	7
Culls (including windfalls)	do....	90.7
Percentage of merchantable fruit		7.2

It will be seen that of the crop from the unsprayed trees, 97.7 bushels, only 7 bushels were merchantable. In practice, the cost of labor for gathering and sorting such fruit would be more than its value, and the crop from the unsprayed trees would be, therefore, practically a complete loss, except for cider or evaporation.

In the same orchard the fruit from a block of 69 sprayed Winesap trees was sorted, as in the case of the Ben Davis, yielding—

Merchantable fruit	bushels..	255
Culls (including windfalls)	do....	36.5
Percentage of merchantable fruit		87.4

The crop from 10 unsprayed Winesap trees yielded as follows:

Merchantable fruit	bushels..	6.75
Culls (including windfalls)	do....	10.25
Percentage of merchantable fruit		39.7

The fruit classed as merchantable on the unsprayed Winesaps, namely, 6.75 bushels, was notably smaller than on the sprayed trees, 731 apples being required to fill a barrel as against 612 apples from the treated trees.

RESULTS IN MISSOURI.

In the Hansell orchard at Fordland, Mo., the fruit from 49 sprayed Jonathan trees, when classified, gave the following results:

Merchantable fruit	bushels..	121.5
No. 1's	do....	108
No. 2's	do....	13.5
Culls (including windfalls)	do....	11.29
Percentage of merchantable fruit		91.4

From 34 unsprayed Jonathans the yield was—

Merchantable fruit	bushels..	51
No. 1's	do....	24
No. 2's	do....	27
Culls (including windfalls)	do....	39.6
Percentage of merchantable fruit		56.2

Practically all the injury was due to the codling moth.

In the same orchard the fruit from 39 sprayed Gano trees gave results as follows:

Merchantable fruit	bushels..	258
No. 1's	do....	207
No. 2's	do....	51
Culls (including windfalls)	do....	37.37
Percentage of sound fruit		87.3

From 14 unsprayed Gano trees the yield was as follows:

Merchantable fruit	bushels..	42
No. 1's	do....	21
No. 2's	do....	21
Culls (including windfalls)	do....	39.5
Percentage of sound fruit		51.5

MATERIALS FOR SPRAYING.[a]

Bordeaux mixture with an arsenical added is the most effective treatment for the principal diseases of the fruit and foliage of the apple and for the codling moth. This combined fungicide and insecticide intelligently applied to the trees in the form of a spray should enable the orchardist to protect from the attack of these pests from 85 to 95 per cent of his crop, as has been demonstrated by these tests and shown in the earlier pages of this bulletin.

BORDEAUX MIXTURE.

Bordeaux mixture is composed of copper sulphate (bluestone) and quicklime, with a certain quantity of water. The amounts of copper sulphate and of lime to be used with a given quantity of water vary somewhat, according to the kind of plants or trees to be sprayed and the disease to be treated. When used on the apple the following formula is quite satisfactory for general orchard work:

Copper sulphate (bluestone)	pounds..	5
Quicklime	do....	5
Water to make	gallons..	50

The foregoing formula was used throughout the bitter-rot work in the Lincoln orchard, but a weaker mixture composed of 4 pounds of bluestone and 6 pounds of lime to 50 gallons of water was mostly used in all the other orchards, in the belief that the latter would be less injurious to fruit and foliage; this, however, did not prove to be the case.

[a] For a fuller discussion of fungicides and their preparation and types of spray outfits, see Farmers' Bulletin No. 243, entitled "Fungicides and Their Use in Preventing the Diseases of Fruits," by M. B. Waite. Also, for a discussion of insecticides and their use, see Farmers' Bulletin No. 127, "Important Insecticides," by C. L. Marlatt.

Directions for making.—If large quantities of Bordeaux mixture are to be used, stock solutions of the bluestone and lime should always be prepared, thus saving the time necessary to dissolve the materials. A stock solution of the copper sulphate may be made by dissolving it at the rate of 1 pound to each gallon of water. Fill a 50-gallon barrel two-thirds or three-fourths full of water, and place a sack (or box with perforations in the bottom and sides) containing 50 pounds of copper sulphate in the upper part of the barrel, suspending it by a string or copper wire. In from twelve to twenty-four hours the sulphate will have entirely dissolved, and the sack or box should be removed and enough water added to fill the barrel. After slight stirring, the solution is ready for use. The stock lime may be prepared by slaking 50 pounds in a barrel or other vessel, and finally adding water to make 50 gallons. In slaking the lime, sufficient water should be used to prevent burning, but not enough to drown it, and the mass should be continually stirred with a shovel or spading fork until a thin paste is formed. Stock preparations of both the lime and bluestone may, during warm weather, be prepared at twice this strength, that is, 2 pounds to each gallon of water, but it is difficult to slake more than 50 pounds of lime in a barrel, and when a larger quantity is to be prepared a box in which the lime may be spread out should be used. Barrels containing stock solutions should be kept tightly covered to prevent as much as possible the evaporation of the water, which would give a more concentrated stock solution. Preparatory to use, any water known to have been lost by evaporation should be added, to maintain the proper strength. In making Bordeaux mixture take the necessary quantities of the stock copper sulphate and the stock lime solutions to give the formula in the total amount of water to be used, and place each in separate elevated dilution tanks, which should hold half as much as the total capacity of the spray tank. Thus, if the spray tank holds 200 gallons each dilution tank should hold 100 gallons, and according to the above formula 20 pounds of copper sulphate (20 gallons of the stock solution) and 20 pounds of lime (20 gallons of the stock solution) would be required. To each dilution tank, water should be added (one-half the total amount of spray) and, after stirring, the diluted ingredients are allowed to run through separate hose or troughs attached to faucets at or near the bottom of the tanks, into the strainer on the spray tank, where the two solutions come together, producing the Bordeaux mixture; or, the diluted solutions may be run directly into a mixing tank alongside, the Bordeaux mixture being conducted thence by a hose directly to the spray tank. In extensive operations the latter method is perhaps to be preferred, as more than one batch of the Bordeaux mixture may be prepared somewhat in advance of the arrival of the spray wagon, effecting a slight saving in

time. Only the quantity which can be used during the day should be mixed, as the Bordeaux mixture deteriorates on standing.

In case the dilution tanks are not elevated to admit of filling the spray tank by gravity, the diluted solutions must be dipped and poured into the latter by hand, a bucketful of each simultaneously. This method is only advisable in small operations, where a few barrels at most are needed.

The stock solutions should never be poured together before being diluted, as a coarse, heavy, unreliable mixture will result instead of the light, flocculent preparation that characterizes properly made Bordeaux mixture.

It is important that Bordeaux mixture should be thoroughly strained in order to keep out any coarse particles that would clog the spray nozzles, and it is a good practice to strain the stock solution of lime upon pouring it into the dilution tank. The best material for a strainer is brass wire netting of about 20 meshes to the inch.

Mixing platform for Bordeaux mixture.—In the preparation of Bordeaux mixture in any considerable quantities, some form of elevated platform is almost indispensable, so that the diluted solutions or the mixture may be conducted by gravity directly to the spray tank on the wagon. The platform should be amply large to accommodate the necessary barrels and tanks (at least 10 by 12 feet). Strong and durable materials should be used in its construction, and a well-made platform should last for several years.

The water supply.—An ample water supply will often be at hand in or near the orchard, and the mixing platform must be constructed convenient to it. A supply through pipes or from a water tank is a desirable part of the outfit. The water tank may be separate, as on a windmill tower, or may be placed on the mixing platform above the level of the top of the dilution tanks.

This may be kept filled with a hand pump, but preferably with a pump run by windmill or other form of power. By these means the dilution tanks are most conveniently filled. A cheaper but less convenient way is to pump the water directly from a well, spring, or pond into the dilution tank. If a hillside is available it will be convenient to construct the platform against the hill, a road being made on the lower side as a driveway for the spray wagon, while the chemicals may be delivered at the upper side. A good spring of water, somewhat above the platform, furnishes an ideal location, the water being conducted by troughs or pipes into the water tank on the platform. Sometimes the water is drawn from a pond beneath the edge of the platform by means of a chain pump and delivered through a trough into the tanks and barrels. This is an excellent arrangement where the water supply is thus convenient, but lacks the desirable feature of a storage water tank.

ARSENICALS.

Several arsenical poisons are available for use, such as Paris green, Scheele's green, arsenite of lime, and arsenate of lead. These all contain arsenic and destroy insects which eat them with their food. In the work herein reported Paris green and arsenate of lead were used. A good quality of Paris green is very satisfactory, and this poison is perhaps more generally used than all other arsenicals combined. It should be used on apple at the rate of about 1 pound to 150 gallons of water or Bordeaux mixture, in which case it is simply added to the mixture, having previously been worked into a paste with water, to insure its more thorough distribution in the fungicide. Many growers use it at the rate of 1 pound to 100 gallons of spray, but there is danger of injury to apple foliage at this strength. When used alone in water the milk of lime from slaking 2 or 3 pounds of good stone lime for each 50 gallons should be added, which will neutralize any free arsenic and prevent burning. The same result is secured by the excess of lime in the Bordeaux mixture.

The arsenate of lead was purchased from the manufacturer and used at the rate of 2 pounds for each 50 gallons of Bordeaux mixture. This arsenical, as found on the market, usually occurs in the form of a thick paste, which must be entirely worked free in a small amount of water before being added to the spray tank.

Arsenate of lead has been found preferable to Paris green by some experimenters, as a much greater quantity may be used without injury to the foliage, and it adheres longer. However, when used with Bordeaux mixture Paris green is not readily washed off by rains, is apparently as satisfactory as the former, and at the strength used costs less.

Scheele's green is similar to Paris green, but contains no acetic acid. Being a finer powder, it remains in suspension longer, and costs about one-half less.

Arsenite of lime is much the cheapest of the arsenicals used in spraying, and has been found to be quite efficient. It may be prepared according to the following formula:

White arsenic	pound..	1
Sal soda (crystals)	pounds..	4
Water	gallon..	1

All of the ingredients are boiled together for a few minutes, or until dissolved, and any water lost by evaporation added. This constitutes a stock solution, which will keep indefinitely, 1 pint being used with each 40 or 50 gallons of Bordeaux mixture or water. If used with water, the milk of lime from slaking 2 or 3 pounds of good stone lime must be added to produce the arsenite of lime and the

color of the spray will show how thoroughly the spraying is being done. When used in Bordeaux mixture, no additional lime will be necessary.

In the use of poisons around the home the greatest care should at all times be exercised to prevent accidents. All packages and bottles containing poison should be plainly labeled and kept locked up. Utensils used in preparing poisons for sprays should be thoroughly washed after use.

EQUIPMENT FOR SPRAYING.

With other conditions favorable, the orchardist will not be able to secure satisfactory results in spraying unless he uses an efficient spraying outfit. The outfits in use in some orchards are a practical handicap to good work. There are now on the market many different makes of spray pumps, and some of them are quite efficient and successful. The orchardist can not afford to use any but the best.

The barrel type of pump is largely used in small to medium-sized orchards, and when properly fitted with hose of sufficient length, a good agitator, and nozzles, very effective work may be done. The pump, according to its design, is fitted to the end or side of an ordinary 50-gallon kerosene or similar barrel, which is mounted on a sled, on wheels, or, better, placed in a cart or wagon. One man is required to pump, and one or two men to handle the nozzles, depending on whether one or two leads of hose are used. A good barrel pump should supply two leads of hose, each with double nozzles. Tank outfits are mostly used in the larger orchards, but are very desirable for the small orchardist as well. These consist of rectangular or half-round tanks, flat on top, holding from 100 to 300 gallons of the spray mixture, fitted to the wagon in place of the wagon bed. Some growers use a 100 to 200 gallon hogshead tank placed on one end of the wagon. The barrel type of pumps may be used on these tanks, but it is better to use the larger tank pumps made for the purpose with suction hose. The hole in the top of the tank should be covered with a close-fitting lid to keep out leaves, twigs, and other trash which would clog the pump and nozzles.

Gasoline, steam, or other power outfits are much superior to the hand-power tank or barrel pumps, and where the orchard interest warrants, a power pump should by all means be used. A much higher pressure may be maintained than is possible with hand pumps, giving a fine, mist-like spray penetrating to all parts of the tree and covering every inch of surface. Sufficient power will be furnished to supply several leads of hose, and the spraying may be done quite rapidly, which is very important, especially in regions where suitable days for spraying are infrequent.

A usual defect in spraying outfits is that the hose is not of sufficient length. Each lead of hose should be from 25 to 35 feet long (or from 50 to 75 feet where the second row on each side is to be sprayed) and provided with an 8 to 12 foot bamboo extension rod. This length of hose will permit the complete spraying of a tree before leaving it, insuring more thorough work than if but one side is sprayed at a time, and the amount of driving necessary will be reduced by one-half. (See fig. 7.) In spraying apple orchards an extension rod 10 feet in length will ordinarily be required, although shorter or longer rods are frequently used.

The nozzle is perhaps the most important part of the spraying outfit. There are many kinds of nozzles on the market, most of which

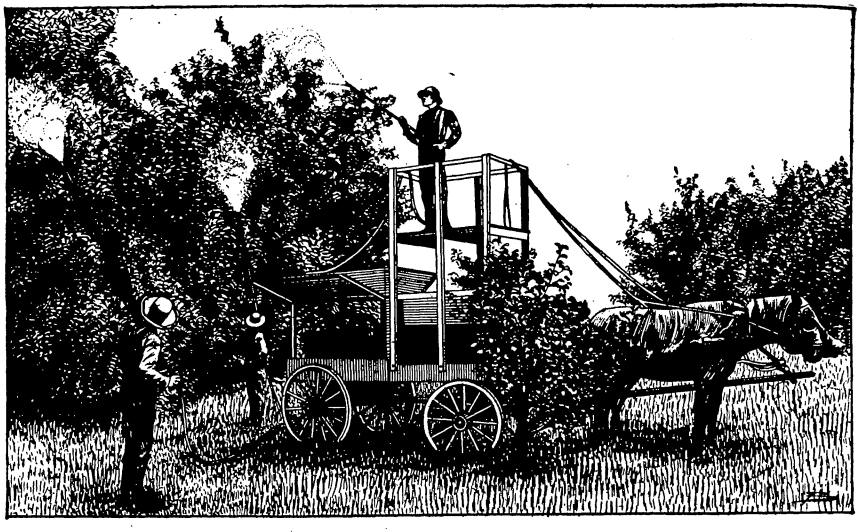

FIG. 7.—Power sprayer at work in the Gipple orchard.

are very unsatisfactory for orchard spraying. The Vermorel type of nozzle is best and should be used. The orchardist should not make the mistake of fitting an otherwise effective spray outfit with a poor nozzle. With hand-power pumps a double Vermorel nozzle for each lead of hose is satisfactory, but for power outfits triple or even quadruple nozzles may be used to good advantage. Many orchardists make the mistake of using nozzles with large apertures, thinking it desirable to discharge large quantities of the liquid. Small or medium-sized openings are required for producing a fine spray.

In spraying high trees some form of elevated platform should be constructed on the wagon, on which one of the nozzle men may stand to spray the higher parts of the trees, the other men spraying from the ground as high as may be reached.

APPLYING THE SPRAY.

Sprays are preventive and not curative, and must therefore be applied before the injury becomes apparent. After a fungus has gained entrance to the foliage or fruit, it can not be reached and the diseased parts made sound again; but the infection may be prevented by coating the parts with a fungicide, such as Bordeaux mixture, which prevents the germination of the spores. Similarly, the codling moth may not be poisoned after it has burrowed into the fruit, but if the poison has been put in the calyx cavities before the calyx lobes close and has been sprayed on the foliage and fruit before the latter is entered by the larvæ, the destruction of the latter in large numbers is insured. Successful spraying, therefore, must be based on a knowledge of the diseases and insects to be controlled. With all of the affections here considered the work should be done in advance of their expected appearance in the orchard. There are two principal reasons why spraying in the hands of some is unsatisfactory, namely, failure to make the applications at the proper time and failure to thoroughly coat the trees and fruit with the mixture. In order to overcome the former difficulty the orchardist must be informed as to the nature of the malady or insect to be treated, and the latter may be overcome by maintaining proper equipment and by giving the necessary attention to thoroughness in spraying.

In the operation of spraying the liquid should be broken into a very fine mist. The nozzles should be so manipulated that every part of the foliage and fruit shall be uniformly covered with fine dots of the spray. It is not necessary that the foliage and fruit should be actually coated with the spray, but every portion should be thickly peppered with it. The higher and inner portions of the tree are commonly insufficiently sprayed, and while the liquid may actually be dripping from the lower branches, the upper parts of the tree may show but little of the spray.

The desired mist-like spray can ordinarily be secured only with high pressure at the pump. This pressure should be not less than 100 pounds, though this is not ordinarily obtained except with gasoline or other power outfits, which should supply a pressure of 125 pounds to 150 pounds. When hand pumps are used the pressure should be maintained as high as practicable, and never less than 75 pounds, in which case good nozzles become more essential for perfect work. To maintain this pressure will require constant hard work, and the tendency will be to allow the pressure to lighten. Except in spraying the tops of trees the nozzle men should never ride in the wagon, even while spraying the smallest trees. In order to reach the inner branches and the underside of the fruit and foliage the operator

must spray from the ground, where he is free to walk around and under the trees. Many failures result from attempts to spray trees from the wagon as the outfit is being driven by.

INJURY TO FOLIAGE FROM SPRAYS.

Under certain conditions there may be in some years more or less russeting of the fruit and injury to foliage from the use of Bordeaux mixture, the injury mostly to the fruit following the applications made soon after the falling of the petals, for the apple scab. In several of the demonstration orchards in the Ozarks and in Nebraska injury to foliage and fruit was noticed. The russeting of the fruit, however, in most cases gradually disappeared as the apples developed, and at picking time was scarcely noticeable. In the Hansell orchard at Fordland a few of the apples at picking time were so russeted as to be undesirable for packing. Also some foliage injury resulted from the July and August applications of Bordeaux mixture and arsenicals, the foliage on the newer growth being in some cases scorched and browned around the edges of the leaves, and in others these became yellow, a small percentage falling. The foliage injury, however, was soon outgrown and by autumn the sprayed trees carried a heavy foliage, whereas the unsprayed trees were practically bare on account of injury from leaf-spot diseases, as already described. (See fig. 3.)

SCHEDULE OF APPLICATIONS.

The following schedule of applications is recommended as a system of orchard spraying for regions where all of the several affections herein considered are likely to occur, as in the Ozarks. The treatment for each of these troubles when considered alone has been given in connection with their discussion in the preceding pages, and where they do not all occur together the orchardist will be able to arrange a combination treatment for his particular troubles. With some varieties, practically immune to scab, the first application may be unnecessary, and the first treatment required is the second one of the schedule, i. e., for the codling moth. In localities, or with varieties immune to the bitter-rot, the last application of Bordeaux mixture may be omitted, or the amount of copper sulphate in the formula reduced.

First application.—Spray with Bordeaux mixture (5–5–50 formula) and an arsenical, after the cluster buds have opened, but prior to blooming. This is the first scab treatment, and is made to prevent that disease from infecting the fruit buds and young, unfolding leaves. The arsenical will destroy any larvæ feeding on the foliage or buds, such as canker worms, bud-moth, etc.

Second application.—Spray with Bordeaux mixture and an arsenical, as 2 pounds of arsenate of lead or 6 ounces of Paris green to 50 gallons of the Bordeaux mixture, immediately after the petals fall. This is the second treatment for scab and the first for the codling moth. Special pains must be taken to fill with the spray the calyx cavity of each little apple, where the poison will be retained to kill the young larvæ as they attempt later to enter the fruit. If this application has not been thoroughly made, a supplemental treatment should be given within a week and before the calyx lobes close, in order to further insure the poisoning of each calyx cavity and afford additional protection against the scab.

Third application.—Spray with Bordeaux mixture and an arsenical, as above, three weeks from the dropping of the petals. This treatment is especially important for destroying codling moth larvæ just as they are hatching from eggs placed here and there on the foliage and fruit. It is also an important treatment in the control of leaf-spot diseases, and in some seasons is necessary for the prevention of scab.

Fourth application.—Spray with Bordeaux mixture and an arsenical, as above, six or seven weeks after the petals fall. This is the first treatment for the bitter-rot and apple blotch diseases, and is also important for the control of leaf-spot. Where the preceding applications have been omitted and the weather conditions (hot and showery) indicate an early infection period, this treatment should perhaps be made a week earlier.

Fifth application.—Spray with Bordeaux mixture and an arsenical, as above, about nine weeks from the close of the blooming period or two weeks later than the fourth application. This constitutes the second application for the bitter-rot and apple blotch diseases, and the first for the second brood of the codling moth. It also affords further protection against leaf-spot.

Sixth application.—Spray with Bordeaux mixture and an arsenical, as above, about twelve weeks after the petals fall or three weeks after the fifth application. This constitutes the second application for the second brood of the codling moth and the third for the bitter-rot and apple blotch diseases.

FARMERS' BULLETINS.

The following is a list, by number, of the Farmers' Bulletins available for distribution. The bulletins entitled "Experiment Station Work" give in brief the results of experiments performed by the State experiment stations. Titles of other bulletins are self-explanatory. Bulletins in this list will be sent free to any address in the United States on application to a Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C. Numbers omitted have been discontinued, being superseded by later bulletins.

22. The Feeding of Farm Animals. Pp. 40.
24. Hog Cholera and Swine Plague. Pp. 16.
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28. Weeds: And How to Kill Them. Pp. 30.
29. Souring and Other Changes in Milk. Pp. 22.
30. Grape Diseases on the Pacific Coast. Pp. 15.
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34. Meats: Composition and Cooking. Pp. 31.
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36. Cotton Seed and Its Products. Pp. 16.
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